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CONTENTS

PAGE

BROWN, E. S., B.A., F.R.E.S. The nymphal stage of *Capnia atra* Morton (Plecopt., CAPNIIDAE), with a description of certain distinguishing features . . . . . 50–53, 4 figs.

DONISTHORPE, Horace St. J. K., F.Z.S., F.R.E.S., and MORLEY, D. B. Wragge, B.A., F.Z.S., F.L.S., F.R.E.S. A list of scientific terms used in myrmecology . . . 43–49

EWER, R. F. The effect of grain size on the oviposition of *Calandra granaria* Linn. (Coleoptera, CURCULIONIDAE) . . . . 57–63, 1 fig.

FRASER, Lt.-Col. F. C., I.M.S., Retd., F.R.E.S. A note on the importance of *Eolestes synthetica* Cockerell in the phylogeny of the Odonata . . . . 54–56, 1 fig.

RAHMAN, Khan A., B.Sc. Agric. (Edin.), Ph.D. (Cantab.). The Indian honey-bee (*Apis indica* F.) (Hymenoptera) at Lyallpur 33–42

BOOK NOTICES 64

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THE INDIAN HONEY-BEE (*APIS INDICA* F.) (HYMENOPTERA) AT LYALLPUR

By Khan A. Rahman, B.Sc. Agric. (Edin.), Ph.D. (Cantab.).

(*Entomologist to Government, Punjab, Lyallpur.*)

Contents.

Page
1. Introduction 33
2. Résumé of attempts 33
3. Climate and bee-flora of Lyallpur 34
4. Fundamentals of acclimatization 34
5. Seasonal management 35
6. Honey-flow 37
7. Honey yields 39
8. Bee enemies 39
Literature 40

1. Introduction.

Three species of honey-bee, namely, the Little honey-bee (" chhoti makhi "; *Apis florea* F.), the Giant or Rock honey-bee (" dumna " or " bhandaur "; *Apis dorsata* F.) and the Indian honey-bee (" darohla " or " mahun "; *Apis indica* F.) are found in India. In the Punjab the Little honey-bee is a permanent resident of the plains only, while the Indian honey-bee is a permanent resident of the hills and is at present confined to the Kangra and Kulu Valleys and to the Simla, Murree and Dalhousie Hills. The Giant bee lives both in the plains and in the hills up to a height of 3000 feet above sea level. The highest place where it has so far been found is Solang-gahar (8000 feet above sea level) and the lowest Nurpur (1440 feet above sea level) where it is met with only infrequently. It appears to be abundant, however, between 2000 and 6000 feet above sea level. The distribution of *Apis indica* F. has restricted its honey-gathering and pollinating services to the hilly tracts which comprise about one-sixth (or less) of the area of the British Punjab. In order to extend its utility and field of activity, work on the acclimatization of *Apis indica* F. in the plains of the Punjab was taken up at Lyallpur in 1934. This was an uphill task demanding very patient labour, and after careful investigations we have succeeded in evolving simple methods for keeping it at Lyallpur. This paper embodies the results of those investigations.

2. Résumé of Attempts.

Work on the acclimatization of *Apis indica* F. at Lyallpur was taken up by my predecessor, K. B. M. Afzal Husain, in November 1934, with three colonies imported from the Kulu Valley. These did well during December 1934 and the spring of 1935, after which they steadily dwindled and finally perished in the beginning of August 1935. Two colonies were imported from the Kangra District in November 1935, three in November 1936 and three in November 1937; but in every case the bees perished by June or July.

Again four colonies were imported from the Kulu Valley in November 1938. Three of these colonies perished in June 1939, while the fourth one survived until 5th September 1939, when its queen was found dead at the entrance of the hive. In November 1939 six colonies were once more imported from the Kulu Valley as usual. These were carefully looked after and their wants were closely studied and attended to. The bees made good progress and were increased to 8 colonies in the spring of 1940, when (in March) their queens were renewed. These colonies lived through the summer of 1940 successfully. During the winter of 1940 and the spring of 1941 they were increased to 16 by sub-division. Two out of these sixteen were kept as controls, while the queens of the remaining 14 colonies were renewed in March 1941. The two colonies kept as control perished in June–July 1941, but the 14 colonies with renewed queens came through the summer successfully and were increased to 24 colonies by sub-division during the spring of 1942. Five colonies out of these 24 became very weak and were united with the other colonies, leaving behind 19. Out of these one perished, one was sent out of Lyallpur and two which had been kept with old queens as controls perished in July 1942. The remaining 15 colonies " summered " successfully during 1942. In December 1942 thirteen more colonies were imported from Katrain and Nagrota. Thus in 1943 there were 28 colonies at Lyallpur. This number was increased to 43 during the spring by natural and artificial swarming. Forty colonies out of these 43 " summered " successfully during 1943 and the remaining three became very weak and were united with other colonies. These colonies were increased to 70 during February–March 1944.

3. CLIMATE AND BEE-FLORA OF LYALLPUR.

Lyallpur is situated between 31° 49′ N. and 73° 38′ E. at a height of 605 feet above sea level.

Prior to colonisation " ber " (*Zizyphus jujuba* L.), " mallha " (*Zizyphus nummularia* W. & A.), " kikar " (*Acacia arabica* Villd.), and " shisham " (*Dalbergia sissoo* Rox.), were rare. Since the development of scientific agriculture here the climate and flora of Lyallpur have undergone enormous changes. The rainfall has risen from 4·95 in. in 1896–97 to 18·02 in. in 1942–43; and the maximum temperature of 121° F. has now dropped to 116° F. Appendix I gives the average temperature and humidity, month by month, of Lyallpur for the last 4 years. The crops and trees now commonly found are wheat, cotton, sugar-cane, maize, " bajra " (*Pennisetum typhoideum*), " berseem " (*Trifolium alexandrinum*), " toria " (*Brassica napus* var. *dichotoma*); " sarson " (*Brassica campestris* var. *sarson*), Citrus spp.; plum, guava, peach, loquat (*Eriobotrya japonica*); mango, " jamen " (*Eugenia jambolana*); eucalyptus, " shisham," " arjun " (*Terminalia arjuna*); " amaltas " (*Cassia fistula*); cucurbits, radish, turnips and rose. " Kikar " and " shisham " are abundant as roadside and canal-bank trees.

During the last four years *Apis indica* F. has been seen visiting 69 plants at Lyallpur (see Appendix II).

4. FUNDAMENTALS OF ACCLIMATIZATION.

The common practice among Indian bee keepers is to allow a queen to head the colony as long as she continues laying eggs and then to change her if the bees have not already superseded her. The same practice was followed at Lyallpur in the case of all imported colonies of *Apis indica* F. up to 1939. From November to May is the period of nectar secretion at Lyallpur, and in order to enable a colony to take full advantage of it a queen has to lay eggs at top speed. This puts a heavy strain on her egg-laying capacity, with the result that after May she is exhausted and is unable to lay a sufficient number of eggs to compensate for the death of workers due to (*a*) overwork in keeping the colony cool, and (*b*) bee enemies. This fact, coupled with the scarcity of bee-flora during June–October, hastens the doom of the colonies. Thus the fundamentals of acclimatization of *Apis indica* F. at Lyallpur have been found to be two :—(1) a young vigorous queen in summer, and (2) the provision of natural food during the season of scarcity. Oviposition by the queen acts as an incentive for the workers, and collection of food by the workers from outside acts as an incentive for the queen. Thus the idea was conceived of replacing the queens in February–March by young vigorous queens to head the colonies. On being put to test, this device was found to be most helpful in enabling *Apis indica* F. to " summer " successfully at Lyallpur.

In order to provide natural food for *Apis indica* F. during scarcity, particularly during June–September, various plants were tested and it was found that *Portulaca*, *Lagerstroemia* and " deela " grass (*Scirpus maritimus*) provided sufficient pollen for the bees during this period.

5. SEASONAL MANAGEMENT.

The climate of Lyallpur is vastly different from the climate of the natural home of *Apis indica* F., *i.e.*, in the hills of the Punjab.[1] This fact necessitated the evolution of methods of management to suit the changed conditions under which the bee was expected to live and thrive.

Winter management :—Bee keepers winter season extends from November to February. From the bee-keeping point of view, winter at Lyallpur, as indeed throughout the plains of the Punjab, is to all intents and purposes similar to the autumn of the Kulu Valley and therefore a very important period for the bee keepers. Nectar and pollen are available in abundance in the fields. The bees rear brood, collect surplus honey, and swarm during this season. The range between the night and day temperature is as wide as 40° F. to 70° F. in the open. Special precautions had, therefore, to be taken (*a*) to prevent the bees from consuming large quantities of honey, (*b*) to safeguard against the chilling of the brood, and (*c*) to give them all facilities to continue their field work normally and uninterruptedly. In order to achieve all these objects it was found most suitable with the advent of winter to pack the colonies in such a way that they could be easily examined and their needs attended to. After due experimentation it was found that for the colonies lying under a roof (*e.g.*, a shed or a verandah) a three-inch-thick packing of sugar-cane trash (called " khori "), rice or wheat straw, or dry leaves, on all sides of the hive, held in position by gunny cloth, was the best for the purpose; but when the colonies were lying in the open under a tree, covering the packing with some water-proof material (*e.g.*, sisalkraft paper) was found to be essential to prevent it from getting wet during winter rains.

It was observed that colonies, unlike those in the hills, build up their strength vigorously during winter. It was, therefore, found essential to examine them every 7–10 days so as to give them extra combs if and when necessary. In order to prevent too much extension of the brood nest it was found best, as a safeguard against chilling the brood, to give extra combs as sparingly as was compatible with necessity. Further it had also been found to be a good expedient to remove to the sides of the hives the frames filled with honey.

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[1] Katrain in the Kulu Valley is a typical representative of the natural home of this bee.

Spring management:—Bee keepers spring season extends from March to May. It has been found that during this period brood-rearing activities of the bees are intensified and that those colonies which do not swarm in winter rear brood extensively, gain in strength, and swarm in this season. They continue to collect surplus honey. Since the weather is uncertain during February–March it has been found to be a good plan not to unpack colonies until the weather settles down to normal and becomes fairly warm. The month of March has been found to herald the major honey-flow period in the plains and in order to enable the bees to take full advantage of it, it has been found to be a good practice (*a*) to make up the honey, in the hives which are deficient in it, to 10–15 lb., (*b*) to give extra frames when required, and (*c*) to renew the queens so as to have a young prolific and vigorous queen heading every colony.

Swarming:—Experience with *Apis indica* F. at Lyallpur has shown that it usually swarms during January–April, but if weather conditions are favourable swarming may start towards the end of December and continue until May. Causes which induce swarming are the following: (*a*) a poorly-laying queen, (*b*) lack of space for the queen to lay eggs, (*c*) lack of space for storage of pollen and nectar, (*d*) heat, and (*e*) lack of ventilation in the hive. Because swarming takes place during the honey-flow season also, it was found to be most harmful from the point of view of honey-yield, because a single colony was found to produce 2–7 weak colonies, and none of these could collect enough honey for itself, leave alone any surplus honey for the bee keeper. Control of swarming is one of the most important management practices and the following technique has ultimately been evolved and is being followed with satisfactory results:—

Colonies are allowed to build queen cells and send out a primary swarm which, by the usual practice of sprinkling water on it, is forced to cluster on some object nearby. The swarm is then caught in a basket and hived on the old stand in a new hive. The old hive containing the parent colony is removed from its old stand about thirty yards away. The primary swarm is given a frame of sealed worker brood from the parent or some other colony, a frame of honey and pollen, and either 4–5 drawn frames or 4–5 frames with comb foundation. Strengthened by the field bees of the parent hive, the primary swarm continues to store honey. In the parent colonies young queens which emerge fight it out among themselves and the one that wins heads the colony, mates, and starts egg-laying. All this is completed in a fortnight.

The parent colony with the new queen is then united with the primary swarm on the old stand and its queen (of the primary swarm) killed. In this way the colony is "requeened" without any interference with its normal activities.

The advantages of this method are that the primary swarm is reinforced by the addition of field-bees and is thus able to take full advantage of the honey-flow, while the parent colony, by losing its field-bees, becomes too weak to send out an "after swarm."

Allowing colonies to satisfy their swarming instinct has been found, in some yet inexplicable way, to do them good.

Summer management :—The bee keepers summer period extends from June to October. During this period there is scarcity and dearth of pollen and nectar in the fields and the bees are hard put to it to sustain themselves. Both the inherent capacity of the queen to lay eggs and the strength of the colony are at the lowest ebb. It is during this period that absconding among *Apis indica* F. has been observed to be at its maximum at Lyallpur. An analysis of the mass of data collected at Lyallpur indicates that absconding may be due to the following causes :—

(1) Lack of honey stores in the colony, (2) ravages of bee enemies, (3) high temperature, (4) lack of ventilation in the hives, (5) location of the hive in an enclosure lacking cross-ventilation, (6) robbing of weak colonies by strong colonies, (7) too frequent and prolonged handling, and (8) failure of the queen to lay an adequate number of eggs daily to compensate for the increasing number of deaths. In addition to the introduction of a young, prolific and vigorous queen, 10–15 lb. of honey in the hive, location of the hive under a shed or a tree, and protection from enemies, the following measures have been found to be useful in enabling *Apis indica* to " summer "[2] successfully at Lyallpur :—(1) handling the colonies as little as is absolutely essential, (2) providing better ventilation by placing one or two empty hive bodies above the brood chamber, (3) replacing the inner cover by a wire-gauze screen board, (4) giving full entrance (if there is no danger of robbing), (5) providing plenty of clean water in the apiary for bees, (6) giving a brood frame (containing brood in all stages, with capped brood predominating) to the broodless colonies and feeding them liberally on syrup to stimulate the queen to lay eggs, (7) using wire entrance guard to prevent the bees from absconding; and if they still persist, catching them and hiving them in a new hive with (*a*) drawn combs containing sugar syrup and (*b*) a brood frame, (8) providing adequate laying space by removing frames damaged by wax moth or gnawed by the bees themselves and replacing them by good drawn worker combs,[3] and (9) ensuring a supply of pollen for the bees by planting in suitable places *Portulaca* and *Lagerstroemia* to flower in June–July and " bajra " and maize to flower in August–September. This supply of pollen, which gave work to the worker bees coupled with honey stores in the hive or syrup feeding of the colony, ensured successful brood-rearing in the colony during summer.

6. HONEY-FLOW.

The sequence of honey-flow and pollen supply (from major sources) has been observed to be as follows at Lyallpur :—(For detailed information on this point reference should be made to Appendix II) :—

1. November–December	Honey-flow has been observed to begin at Lyallpur during November when " toria " comes into flower which by supplying pollen and nectar in abundance to the bees helps them in early brood-rearing.
2. December–January	" Toria " flow declines towards the end of December, while " sarson " starts flowering in December after

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[2] In other countries and in the hills of the Punjab the main problem is that of " wintering " the bees.

[3] Giving frames with the comb foundation was not found to serve the purpose as the bees did not draw it during summer.

	which it constitutes the main source of the supply of nectar and pollen during this period.
3. February	"Sarson" flow terminates. Such deciduous fruit trees as plums, peaches, pears, etc. blossom forth and supply nectar and pollen to the bees.
4. March	*Citrus* spp. bloom during the month. Colonies which have got over the swarming fever and are with new laying queens and are otherwise in good trim by the first week of March have been found to take advantage of this flow and collect a surplus.[4]
5. April	"Shisham" comes into flower. It is an important source of surplus honey and as all colonies are in proper condition for storing, each colony has been observed to collect 8–10 lb. or more of surplus honey from this flow [5] if the weather conditions are favourable.
6. April–May	Towards the end of April "jamen," "shaftal" and "berseem" and towards the end of May *Terminalia arjuna* [6] come into flower. These plants constitute a major source of honey, therefore each colony may collect, depending upon whether temperature and humidity are too high or low, 10–30 lb. of surplus honey.[7]
7. June–July	The period of dearth begins with June. *Portulaca* and *Lagerstroemia* have been discovered to be excellent for supplying pollen to the bees during this period, thereby enabling them to keep on rearing brood.
8. August–September	Dearth continues. Towards the end of August "bajra" and maize come into flower and help the bees a great deal by supplying pollen.
9. October	Bee-flora during this month has been found to be at its lowest ebb but as the weather cools down considerably bees manage to pull through it. Only "ber," which supplies pollen and nectar, is in flower during this month.

It will be observed from the above that there are four honey-flows at Lyallpur, namely (1) *Brassica* flow, (2) *Citrus* flow, (3) "Shisham" flow, and (4) combined flow of clovers, "jamen" and "arjun," which follow one another in quick succession. It has been found to be a good practice to extract honey at the end of each flow and to return the empty combs to the bees. This practice reduces congestion as well as providing the bees with ready-made combs for storing honey in the next flow.

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[4] Citrus honey is light amber in colour and mild in flavour.

[5] "Shisham" honey is amber in colour. Usually it is rose-scented—the scent having been derived from pollen grains collected from rose which is in bloom.

[6] *T. arjuna* is a common roadside tree on the Agricultural College Estate.

[7] Honey from "jamen" and clover is water-white to light amber in colour, very mild in flavour and rather thin in consistency.

7. HONEY YIELDS.

A corollary to this success in " summering " colonies is that honey yields have also improved from year to year at Lyallpur as is clear from Table 1 below. As the methods of bee-management improve, honey yield, it is hoped, will increase still further.

TABLE 1.

Showing honey yields in the Experimental Apiary at Lyallpur.

Year	Total no. of colonies	No. of colonies extracted	Total yield		Average yield per colony		Maximum yield from a colony	
			Lb.	Oz.	Lb.	Oz.	Lb.	Oz.
1938–39 .	6	6	49	0	8	3	Not recorded	
1939–40 .	8	8	66	0	8	4	,,	,,
1940–41 .	14	12	154	0	12	13	25	0
1941–42 .	24	20	388	12	19	7	51	0
1942–43 .	40	32	417	8	13	1	60	8

It will be observed from the above table that the highest average yield which has so far been obtained per colony is 19 lb. 7 oz. and the highest yield from one colony 60 lb. and 8 oz. The average yield per colony in 1942–43 was 13 lb. 1 oz. for the reason that the " shisham " flow was ruined by rain and heavy wind storms which occurred when " shisham " was in flower.

8. BEE ENEMIES.

Apis indica F. has been found to have four chief enemies at Lyallpur, namely (1) the wax moth (*Galleria mellonella* L.), (2) a new hymenopterous predator (*Palarus* sp.), (3) Black ants (*Camponotus* sp.), and (4) the Bee-eater (*Merops orientalis orientalis* Lath.). Information collected about them at Lyallpur is briefly summarised below :—

(1) *Wax moth* :—The detailed life-history of this pest has yet to be studied but it has been observed that at Lyallpur (*a*) it has a short life-cycle, and (*b*) it remains active practically throughout the year. Regular cleaning of colonies has proved to be helpful in preventing it from developing in them, while occasional fumigation of surplus combs with sulphur, carbon bisulphide, and para-dichloro-benzene has been useful in preventing it from becoming a nuisance in stores.

(2) *New Hymenopterous predator* :—This wasp has evidently been killing *Apis indica* F. ever since bee keeping was started at Lyallpur, but it remained undetected until May 1940, when it was collected for the first time. It is a gregarious, ground-dwelling wasp which is a veritable tiger for *Apis indica* F. It has been found to remain active in the apiary during May–June when it was observed to kill bees by the hundred.

The wasp was found to be most active between 11 A.M. and 4 P.M. on hot and clear days; it was found to be absent from the apiary on cloudy days and during rains; intensely hot and clear days appeared to be most favourable for its activity. It was found that if there was shade over the hive entrance for about 8–10 feet in front of it, or the entrance of a colony was well protected by a low-growing plant or a creeper, molestation of bees by this wasp was appreciably reduced. When its attack became severe it was kept in check by means of fly swatters: during June (1942), 2432 *Palarus* were killed by fly swatters in the apiary at Lyallpur.

(3) *Black ants* (*Camponotus* sp.) :—Black ants have been found to be active in the apiary mostly during summer and monsoon seasons when they cause a great deal of trouble to the bees. At times they actually raid the colonies in large numbers and force the bees to quit the hive. They were kept under control by the destruction of their nests within 100 feet of the apiary by pouring into them potassium cyanide [8] solution (prepared by dissolving 1 oz. of potassium cyanide in 4 gallons of water). To prevent the ants from crawling up the hives, the legs of the hives were kept in earthen cups (3″ deep and 7″ diameter) filled with water.

(4) *Bee eater* (*Merops orientalis orientalis*) :—This bird breeds during March–August. It lays 4–7 eggs of a pure white glossy colour in serpentine holes which terminate in a cavity.

Since 1939 it had been observed to be active in the apiary at Lyallpur during June and August–December in 1939, March–October in 1940 and March–November in 1941 and 1942.

Bee eaters perch on the electric wires on the eastern side of the apiary and sometimes as many as 50 could be counted sitting on these wires. In May 1938 and August 1943 the stomach contents of 78 and 57 birds were examined and 1–31 and 3–10, with an average of 9·3 and 5·8, bees per bird, were found, respectively. It was found that they could be controlled by being killed daily.

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APPENDIX I.

Showing average temperature and humidity at Lyallpur for the years 1939–1943.

Month	Average temperature in shade		Humidity percentage	Rainfall in inches
	Minimum ° F.	Maximum ° F.		
July	82·67	100·02	68·31	3·57
August	80·78	97·44	72·29	3·02
September	75·17	96·48	66·61	0·93
October	63·99	93·85	59·31	0·077
November	50·16	83·46	72·83	0·00
December	42·23	71·82	89·89	0·8
January	41·05	64·85	92·82	1·26
February	46·73	71·45	86·39	0·86
March	54·96	82·76	68·61	0·46
April	65·56	94·39	52·15	0·22
May	75·40	102·97	39·06	0·47
June	81·77	104·62	52·11	1·07

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[8] Potassium cyanide is a deadly poison and must be used with great caution.

APPENDIX II.

NECTAR- AND POLLEN-YIELDING PLANTS OF LYALLPUR.

January.

1. " Sarson " (*Brassica campestris*).
2. " Raya " (*Brassica juncea*).
3. Turnip.
4. " Taramira " (*Eruca sativa*).
5. Loquat (*Eriobotrya japonica*).
6. Radish.
7. Coriander or " Dhania."
8. *Poinsettia.*
9. Cauliflower.
10. Brinjal.[9]
11. Tomato.[9]

February.

Nos. 1, 2, 3, 4, 5, 6, 7, 9, 10 [9] and

12. Pear.
13. Peach.
14. Plum.
15. Silk cotton tree.
16. Cress (*Lepidium sativum*).
17. Gram.[9]
18. Safflower.[9]

March.

Nos. 7, 10, 11, 13, 14, 15, 16, 17,[9] 18 [9] and

19. Sour lime.
20. Sweet lime.
21. Lemon.
22. Citron.
23. Pomelo.
24. Malta orange.
25. Orange.
26. Mango.
27. Date palm.
28. Fennel.
29. Onion.
30. Safeda (*Eucalyptus* sp.).
31. " Shisham " (*Dalbergia sissoo*).[10]
32. Banana.[9]
33. Pohli.[9]

April.

Nos. 7, 10, 11, 15, 27, 28, 29, 30, 31,[10] 32 [9] and

34. Lucerne.
35. " Jamen " (*Eugenia jambolana*).
36. Carrot.
37. " Sharin " (*Albizzia lebbek*).
38. " Phulai " (*Acacia modesta*).
39. " Lasura " (*Cordya myxa*).
40. " Shaftal" (*Trifolium resupinatum*).[10]
41. " Berseem " (*Trifolium alexandrinum*).[10]
42. " Sainji " (*Melilotus parviflora*).[9]
43. Pomegranate.[9]
44. Long melon (*Cucumis melo* var. *utilissima*).[9]
45. Rose.[9]
46. Corn flower.[9]
47. " Harmal " (*Paganum harmala*).[9]
48. " Ak " (*Calotropis gigantea*).[9]

May.

Nos. 34, 35, 40,[10] 41,[10] 43,[9] 44 [9] and

49. Guava.
50. " Phalsa " (*Grewia asiatica*).
51. " Arjun " (*Terminalia arjuna*).
52. " Amaltas " (*Cassia fistula*).
53. Bottle gourd.[9]
54. Lady's finger.[9]
55. Bitter gourd.[9]
56. *Portulaca.*[9]
57. Cucumber.[9]
58. Melon.[9]
59. *Lagerstroemia.*[9]

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[9] Yields pollen only.

[10] Yields nectar only.

June.

Nos. 51, 52, 53,[9] 54,[9] 55,[9] 56,[9] 57,[9] 58,[9] 59.[9]

July.

Nos. 56,[9] 59,[9] and

60. Sunflower.[9]

August.

No. 60 [9] and

61. Sesame.[9]
62. Maize.[9]
63. " Bajra " (*Pennisetum typhodeum*).[9]
64. " Chari," " Jowar " (*Andropogon sorghum*).[9]
65. Cotton (Bees seen on extra floral nectaries).
66. " Deela " (*Scirpus maritimus*).[9]

September.

Nos. 61,[9] 62,[9] 63,[9] 64,[9] 65 and 66.[9]

October.

No. 8 and

67. " Ber " (*Zizyphus jujuba*).
68. " Toria " (*Brassica napus*).
69. *Cosmos.*

November.

Nos. 2, 8 and 68.

December.

Nos. 1, 2, 3, 8, 68, 69.

A LIST OF SCIENTIFIC TERMS USED IN MYRMECOLOGY

By Horace St. J. K. Donisthorpe, F.Z.S., F.R.E.S., and D. B. Wragge Morley, B.A., F.Z.S., F.L.S., F.R.E.S.

For a number of years past the senior author has been tabulating various scientific terms used and invented by different myrmecologists. The junior author having also collected a number of such terms, it was decided to combine the two lists, and publish a joint paper on the subject.

The terms in the following list consist chiefly of those used only in myrmecology, terms in general use being, with few exceptions, excluded. The authors have endeavoured to make the list as complete as possible. Some terms, however, may have escaped the notice of both of them; they will therefore be grateful to be informed of any such lapses.

They wish to express their thanks to Mr. Q. A. Geering for helping to check some of the references.

Adelphogamy. Mating between brothers and sisters (*i.e.*, the male and female ants produced from eggs laid by the same mother). *Forel.*

Allometrosis. The presence of different species or races of queens in one colony. *Forel.*

Ammochaetae. Long hairs on the lower side of the head which are directed forwards. *Wheeler.*

Arenicolous. Sand living. *Wheeler.*

Auxiliaries. The slaves in the mixed colonies of the slave-making ants. *Lubbock.*

β-*female.* An aberrant female occurring with or without the normal female, and characterised by excessive development in the legs, and in the pilosity of the body. *Wheeler.*

Biocoenosis. The association of individuals of different species. *Wheeler.*

Biota. The fauna and flora comprised by the ants and other insects and plants associated with them (*e.g.*, the Alaskan Biota). *Wheeler.*

Blastophthory. The entire change of the heredity of "all that can no longer be crossed or modified by individual acquisition or education, or even deteriorated by germ-poisoning." *Forel.*

Caespiticolous. Living in fields. *Wheeler.*

Chemotactic sense. The appreciation of chemical differences by means of touch. A form of sense of smell. *Wheeler.*

Chordotonal organs. Organs situated in the tibia of some ants which are thought to be organs of hearing. *Lubbock.*

Chrymosymphily. The friendly relationship between ants and lepidopterous larvae based on the attraction of the scent given off by the larvae. *Kemner.*

Cleptobiosis. The establishment of the nests of smaller species of ants near or on the nests of a larger species; the smaller species feeding on the refuse of the larger species, or waylaying the larger workers on their way home. *Wheeler* (restricted by *Forel*).

Coenobiosis. A definite consociation of animals and plants of different species. *Wheeler.*

Colacobiosis. Permanent social parasitism. *Wheeler.*

Compound nests. Colonies of ants which are composed of more than one species, but in which the brood of each species is kept separate. *Wheeler.*

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Cryptogyne. This name is applied in the case of several genera of ants in which no differentiated females are known to exist, and in which the males mate with individuals indistinguishable from ordinary workers. *Wheeler.*

Desmergate. An intermediate form between the worker and soldier. *Wheeler.*
Diacammatogyne. Workers of the genus *Diacamma* which take the place of the females, the males inseminating them. They possess very minute deciduous fore-wings. *Wheeler.*
Dichthadiigyne. The peculiar female of the DORYLINAE which lacks eyes, ocelli, or wings, and is probably an extreme development of the gynaecoid worker. *Wheeler.*
Dinergate. A soldier ant. *Wheeler.*
Dinergatogyne. An anomalous form which is a combination of soldier and ergatogyne. *Wheeler.*
Dinergatogynomorph. A form never actually discovered, but which would be a genetic mosaic, part soldier, part worker and part female. *Santschi.*
Dorylaner. The wasp-like male of the DORYLINAE. *Wheeler.*
Dulosis. Slavery. *Wheeler.*

Embryogenesis. The " genesis of the species through the egg." *Forel.*
Endosmosis. The passage of nutriment through a fine skin or wall. *Forel.*
Epigaeic. Living above ground. *Wheeler.*
Eremobiotic. Living under conditions where there are no ants. *Farquharson.*
Eremosymbiont. Those insects living in ants' nests which take nothing from, nor give anything to the ants, being completely ignored by them, although gaining some manner of protection. *Farquharson.*
Ergatandromorph. Worker-male genetic mosaic. *Wheeler.*
Ergataner. Worker-form male, having no wings and resembling the worker in the structure of the antennae. *Wheeler.*
Ergatogyne. Female without wings, analogous to the worker. *Forel.*
Ergatoid. Fertile workers, with thorax of worker type, but voluminous gasters and often ocelli. *Wasmann.*
Ergatomorphism. The occurrence of forms analogous to that of the worker *Forel.*
Ergepitropic. Carrying out the care of the brood and food-supplying. *Goeldi.*
Ericeticolous. Living on heaths. *Wheeler.*
Eurythermal ubiquists. Ants flourishing under very variable conditions of temperature. *Zschohke.*

Facultative slavery. The making of slaves by species of ants which are found and can exist without their slaves. *Wasmann.*
Formicarium. An artificial ants' nest used for making observations on their behaviour. *Swammerdam.*
Formicary. The ants' nest. *Johnson.*
Fourmilière double. Colonies of ants which are composed of more than one species, but in which the brood of each species is kept separate. *André (Ernest).*
Fourmilière mixtes. Colonies of ants which are composed of more than one species, and in which the brood of each species is not kept separate. *André (Ernest).*

Gonepitrophy. Carrying out the sexual functions. *Goeldi.*
Granivorous. Grain-eating. *Forel.*
Gynaecaner. A form which resembles the female rather than the male, but has the same number of antennal joints as the latter. It may be winged or wingless. *Wheeler.*
Gynaecoid. An egg-laying worker. *Wasmann.*
Gynandrarchic. In which the male sex is dominant (this term does not apply to ants, which are all gynarchic, but is included because it is the opposite to that term). *Wheeler.*

Gynandromorph. A female-male genetic mosaic. *Meinert* (for ants).
Gynarchic. In which the female sex is dominant. *Wheeler.*
Gynarchy. Dominance of the female sex. *Wheeler.*
Gynergate. A worker-female genetic mosaic. *Wheeler.*

Hamabiosis. Symbiosis in which the relationship is advantageous to both species of ants concerned, and where one species cannot exist without the other. *Janet.*
Haplometrosis. The foundation of a new colony by a single fertile queen. *Wasmann.*
Haplometrotic. Given to haplometrosis. *Wheeler.*
Hermaphroditism. (a) *Primary Hermaphroditism.* The individual has well-developed genital organs of both sexes. (b) *Secondary Hermaphroditism.* The ability of the female ant to become hermaphrodite; fertilising her own eggs from the male sperm retained in her seminal receptacle over a period of years after the initial insemination. *Forel.*
Heteroecism. The changing of hosts. *Wasmann.*
Hetreoecious. Living with different hosts at different periods of the life-history. *Wasmann.*
Hyphaenosymphily. Friendly relationship between some lepidopterous larvae and ants, based on the advantages obtained from the spinning of the larvae. *Kemner.*
Hypogaeic. Living underground. *Wheeler.*

Inquiline. A commensal, or guest; lodger. Inhabitant of an ants' nest; or other creature's (for ants). *Forel.*
Integral symbiosis. A symbiotic relationship in which neither set of individuals or organisms concerned can exist without the other. *Forel.*

Janet apparatus. A particular type of observation nest invented by the myrmecologist Charles Janet. *Forel.*
Johnstonian organs. Certain organs situated in the antennae, the function of which is unknown, discovered by Johnston in 1855. *Forel.*

Kinaesthetic sense. A distance sense : the sense which enables the ants to appreciate the distance which they cover on their way out from the nest when foraging. *Wragge Morley.*
Kinetics. The data appertaining to the methods and speed of movement and their study (for ants). *Wragge Morley.*
Kinopsis. The appreciation of moving objects which pass unnoticed when stationary. *Wallis.*

Lestobiosis. Where species of minute ants make their galleries in the walls of the nests of other, larger, species of ants, living entirely separately, but stealing from the larger ants, which cannot chase them into their small holes. *Forel.*

Macraner. An unusually large form of male. *Wheeler.*
Macrergate. A worker which resembles the female only in its abnormally large size, its structure being that of a worker. *Wasmann.*
Macrochaetae. Long hairs on the lower side of the head which are directed forwards. *Santschi.*
Macrogyne. A female which is larger in stature than the normal female. *Wheeler.*
Macrophthalmic. Having exceptionally large eyes. *Wheeler.*
Macropseudogyne. A pseudogyne which resembles the normal female in size, but has a broader and more convex mesonotum and short vestigial wings. *Wasmann.*

Malaxation. The action of chewing. *Wheeler.*

Meconium. The pellet which comprises all the undigested food of the larva, and which is voided just before pupation. It is usually black in colour and is easily visible *in situ* in most larvae. *Wheeler.*

Mermithaner. An anomalous form of the male caused by the presence of Mermithid nematodes in the gaster. *Donisthorpe.*

Mermithergate. An anomalous form of the worker caused by the presence of Mermithid nematodes in the gaster. *Wheeler.*

Mermithodinergate. An anomalous form of the soldier caused by the presence of Mermithid nematodes in the gaster. *Wheeler.*

Mermithogyne. An anomalous form of the female caused by the presence of Mermithid nematodes in the gaster. *Mrazek.*

Mermithostratiotes. An anomalous form of the soldier caused by the presence of Mermithid nematodes in the gaster. *Vandel.*

Mesopseudogyne. Medium-sized pseudogynes which have a very convex or humped mesonotum and no wings. *Wasmann.*

Micraner. A male which is smaller in stature than the normal form. *Wheeler.*

Microgyne. A female which is smaller in stature than the normal form. *Wasmann.*

Microgyny. The occurrence of microgynes. *Wheeler.*

Micropseudogyne. Small pseudogynes with convex or humped mesonotum and no wings. *Wasmann.*

Micropterogyne. An anomalous form of the female which is somewhat smaller than the normal macropterous female, but has the thorax of the normal female type, although narrower, and only very small or vestigial wings. *Wheeler.*

Mixed nest. Colonies of ants which are composed of more than one species, and in which the brood of each species is not kept separate. *Wheeler.*

Mixtobiosis. Mixed life amongst ants; a collective term which includes all cases of mixed and compound colonies of different species of ants. *Wragge Morley.*

Myrmecochorous seeds. Seeds attractive to ants. *Sernander.*

Myrmecocleptic. Given to stealing food from ants, when one is feeding another (examples—*Lepisma, Dinarda*). *Janet.*

Myrmecological. Concerning myrmecology. *Forel.*

Myrmecologist. A student of myrmecology. *Forel.*

Myrmecology. The scientific study of ants. *Forel.*

Myrmecophagic. Myrmecophiles which feed on the ants. *Janet.*

Myrmecophags. Those myrmecophiles which are myrmecophagic. *Wheeler.*

Myrmecophiles. Animals other than ants found in and around ants' nests. *Wasmann.*

Myrmecophilous. Being, by habit, a myrmecophile. *Wasmann.*

Myrmecophyte. Plant found in symbiotic relationship with ants.

Myrmecophytism. Adjective of myrmecophyte. *Wheeler.*

Myrmecoxenes (= *Myrmecoxeny*, adj.). The true guests of ants, where the relationship is beneficial to both guests and ants. *Wasmann.*

Nemoricolous. Glade fauna. *Wheeler.*

Obligatory slavery. The making of slaves by species of ants which are never found without their slaves. *Wasmann.*

Oecotrophobiosis. The reciprocal feeding between adults and larvae. *Rabaud.*

Panmixia. Genetic swamping. *Wheeler.*

Parabiosis. Introduced to describe the special relationship between the Colombian *Crematogaster parabiotica* F. and *Dolichoderus debilis parabiotica* F., where the broods are kept separate, but both species of ants use the same roads when going out to forage. *Forel.*

Parasitoidism. Where "the . . . parasitic insects are really refined predators, which usually, on growing to their full stature, kill the hosts they have been carefully sparing and, one might say, using as food-getting instruments." *Wheeler.*

Partial symbiosis. A symbiotic relationship in which either one species is fully dependent on one or more others which themselves can exist without it, or where the two species concerned can do without each other, but are normally found together. *Forel.*

Phoresy. The utilisation of ants by other insects or animals to carry them from one place to another. *Janet.*

Photodermatic sense. The perception of light by the skin without the aid of eyes. *Forel.*

Photophobic. Disliking light. *Wheeler.*

Phragmosis. The closing of the nest entrance with the anterior portion of the head. *Wheeler.*

Phragmotic. Given to phragmosis. *Wheeler.*

Phthisaner. A pupal male which in the larval or semi-pupal stage has had its juices partially extracted by an *Orasema* larva and is unable to pass on to the imaginal stage. *Wheeler.*

Phylacobiosis. Where certain species of ants live in the nests of termites, and appear to be on friendly terms with the latter, helping to defend the colony. *Wasmann.*

Physergate. Large workers with distended gasters and well-developed ovaries capable of producing eggs, but having mainly the function of honey reservoirs. *Wheeler.*

Physogastry. Excessive enlargement of the gaster. *Wheeler.*

Phthisergate. A pupal worker which has arisen in the same way as a phthisogyne. *Wheeler.*

Phthisodinergate. A pupal soldier which has arisen in the same way as a phthisogyne. *Wheeler.*

Phthisogyne. A pupal female which in the larval or semipupal stage has had its juices partially extracted by an *Orasema* larva and is unable to pass on to the imaginal stage. *Wheeler.*

Phytophily. The trophic relations of ants to plants. *Wheeler.*

Pleometrosis. The alliance of several queens to found a colony. *Wasmann.*

Pleometrotic. Given to pleometrose. *Wheeler.*

Plesiobiosis. The occurrence of two entirely separate colonies of different species of ants under the same stone, or in the same hillock. *Wheeler.*

Podometric sense. Sense that measures walking. *Piéron.*

Polycalic. Large colonies consisting of a mother nest and a number of subsidiary nests. *Forel.*

Polydomous. Having a number of fungus-gardens in different cells. *Weber.*

Polygyny. Having several queens. *Wheeler.*

Prarinicolous. Living in meadows. *Wheeler.*

Primary allometrosis. Alliance between females of different species, or races, to found a colony:

(*a*) Alliance between females of different species.

(*b*) Alliance of females of different races in colony founding. *Wasmann.*

Primary pleometrosis. The alliance of two or more females of the same species and race to found a colony. *Wasmann.*

Prosalient. Leaping forward. *Wheeler.*

Protodichthadiigyne. A highly fertile form intermediate between the ergatoid and the dichthadiigyne. *Wheeler.*

Proventriculus. The crop, or social stomach, of the ant.

Psammophorae. Long hairs on the lower side of the head which are directed forwards. *Forel.*

Pseudogyne. Abortive females produced in some colonies of *Formica sanguinea* Latr., and a few related species, which are supposed by some myrmecologists to be connected with the presence of certain beetles of the genus *Lomechusa* in the nest. They do, however, sometimes occur when these beetles are absent. *Wasmann.*

Psychogenesis. The development of the mind. *Wheeler.*

Pterergate. A worker of normal form, but bearing vestigial wings. *Wheeler.*

Pterodinergate. The soldier analogue of the pterergate. *Wheeler.*

Repletes. Workers with enormously swollen crops who are used by the rest of the colony as living reservoirs for honey-dew. *McCook.*

Retrosalient. Leaping backwards. *Wheeler.*

Scolopal bodies. Special cells of the chordotonal organs. *Forel.*

Secondary pleometrosis. The presence of a number of queens of the same species and race in one colony, which first comes about in the way of supplement either by :—

(*a*) The breeding of females of the same colony which have been fertilised in or near the nest.

(*b*) The adoption of females from strange colonies of the same species and race.

(*c*) By the alliance of different colonies of the same species and race. *Wasmann.*

Semipupa. Pupae in which the wings do not increase in size, since they have reached the acme of their growth in the fully developed larva. Traces of the wings are visible in the semipupa. *Packard.*

Senso-motility. A sense that is supposed by some myrmecologists to exist amongst ants, which enables the ant to appreciate its turning without the aid of extrinsic data. *Forel.*

Silvicolous. Living in woods. *Wheeler.*

Stenothermal (stenotherm basaltliebend). Living between a narrow range of cold temperatures. *Wheeler, after the German.*

Strigilators. The group of synoeketes which live by licking the oily body-secretions peculiar to some ants, small crickets, etc. *Wheeler.*

Symbiogenesis. The development of symbiotic relationships. *Wheeler.*

Symphiles. The true "guests" of ants, where the ants regurgitate honey-dew to the guests, clean them, or otherwise tend them and bring up their young. *Wasmann.*

Synclerobiosis. Mixed nests of uncertain origin and meaning. *Wasmann.*

Syndiacony. The relationship between ants and plants where both obtain some benefit from the other. *Forel.*

Synechthrans. The "guests" in ants' nests which are treated with hostility, often eating the ants or their young, and hiding from their attack (= Hostile Persecuted Lodgers). *Wasmann.*

Synoekete. Indifferently tolerated "guest" in ants' nests. *Wasmann.*

Syntrophy. Where the ants in licking their eggs, feed mites among the egg-masses. *Janet.*

Tachygenesis. Acceleration of the ontogenic development. *Wheeler.*

Teratogyne. A later name given by Wheeler to replace his earlier β-female. *Wheeler.*

Topochemical smell. A sense of smell, supposed by some myrmecologists to exist amongst ants, which enables the ant to appreciate the "topography of the places surrounding it by means of chemical emanations, which give an odour to objects." "Ecphorized smell." *Forel.*

Trichomes. Tufts of golden-yellow hairs found on the bodies of many myrmecophilous beetles, etc. *Wheeler.*

Troglodytic. Living entirely underground. *Wragge Morley.*

Trophallaxis. The reciprocal feeding between adults and larvae. *Wheeler.*

Trophidium. The first larval stage in the PSEUDOMYRMINAE which possess extraordinary appendages: exudatory papillae which form a cluster round the mouth. *Wheeler.*

Trophobiosis. The relations of ants with *Phytophthora*, etc. *Wheeler.*

Trophobiotic. Given to trophobiosis. *Wheeler.*

Trophobionts. Alien insects which live outside the nest and are " milked " by the ants. *Wheeler.*

Trophogeny. Caste-determination by differential feeding, or other nutritional mechanism. *Wheeler.*

Trophorhinium. An organ situated above the trophothylax in the PSEUDOMYRMINAE which consists of two flat, opposable plates, the dorsal and ventral surfaces of the buccal cavity, furnished with very fine striae and minute chitinous spinules. This may be a stridulatory organ. *Wheeler.*

Trophothylax. A special large food-sac, situated just behind the mouths of ants of the genus *Pseudomyrma*. *Wheeler.*

Turner's Circling. The circling of the home-coming foraging ant when it nears the orifice of the nest.

Xenobiosis. The type of nest-community in which " guest ants " occur; where the relationship is of a compound nature, but very intimate, the " guests " never being found except in association with the host species. *Wheeler.*

Xerothermic fauna. The special fauna found in places where warm and dry conditions prevail. *Forel.*

THE NYMPHAL STAGE OF *CAPNIA ATRA* MORTON (PLECOPT., CAPNIIDAE), WITH A DESCRIPTION OF CERTAIN DISTINGUISHING FEATURES.

By E. S. Brown, B.A., F.R.E.S.

There are three known British species of the stonefly genus *Capnia* Pictet, namely *C. nigra* Pictet, *C. vidua* Klapálek and *C. atra* Morton. The first of these is fairly common on the stony shores of lakes; the second and third are described by Hynes (1940) as " not common " and " rare " respectively, the type of habitat frequented being unknown; *C. atra* has been recorded from a few localities in Scotland.

The nymph of but one of these British species has been hitherto described, that of *C. nigra* (see Hynes, 1941 : 498–9); the nymph of another European species (*C. conica* Klapálek) has been described by Kühtreiber (1931). It is with pleasure, therefore, that I am able to report the discovery of the early stages of *C. atra* in a haunt where it was breeding freely.

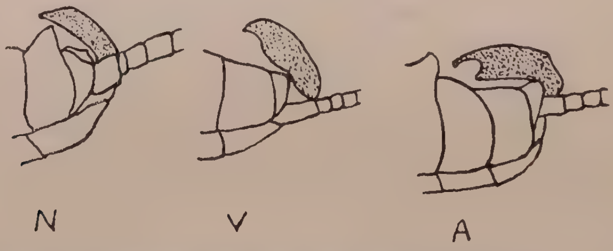

Fig. 1.—Tip of adult ♂ abdomen, from left side. N, *Capnia nigra*; V, *C. vidua*; A, *C. atra*. After Hynes. The supra-anal lobe is shown in outline only, and stippled to accentuate the shape. × 25.

The locality was St. Mary's Loch, in the Scottish county of Selkirk; on 24 March 1944, among stones at the lake margin, adult males of *C. atra* were common, and three nymphs of a species of *Capnia* were found in the same place. On ascertaining that the nymph of this species had not been discovered, I determined to re-visit the locality and obtain sufficient material to draw up a description. On March 28th, more adults were taken, including a great preponderance of males over females of *C. atra*, and, to my considerable disturbance, some adults of *C. nigra*; it became evident that, the *Capnia* colony being impure, care would have to be taken to separate the nymphs of the two species before a description was possible. A further visit on April 1st again produced adults of both species, and a number of nymphs were collected for rearing to maturity; it was found that nymphs of both species were present in the population, and that although in the male they could be easily distinguished, the females were extremely similar and no character has yet been discovered on which this sex can be specifically identified with certainty.

Distinguishing features of the male nymph.—Hynes (1941) pointed out that the male nymph of *C. atra* would probably prove to be distinguishable from that of *C. nigra* by the presence of wing rudiments, since the adult male of the former species is fully-winged, while that of the latter is short-winged. This has proved to be the case, and the distinction is illustrated in fig. 3. The male nymph of *C. vidua*, when it is discovered, should therefore in this respect prove similar to that of *C. nigra*, since the adult male is short-winged.

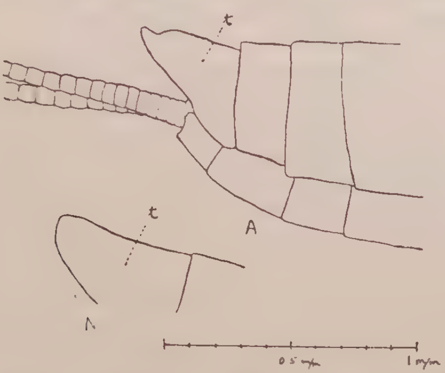

FIG. 2.—A, tip of abdomen of ♂ nymph of *Capnia atra*, from right side; t, tenth tergum; N, tenth tergum of ♂ nymph of *C. nigra*, to show the difference in shape.

Another good distinction was found, which might also have been predicted from adult structure. The supra-anal lobes of the adult males of *C. nigra*, *C. vidua* and *C. atra* differ in a comparative manner in shape as seen in profile (fig. 1); that of *C. nigra* has no emargination at the tip, that of *atra* is strongly emarginate, and that of *vidua* is intermediate. In the male nymphs the tenth tergum, which evidently becomes turned over forwards to produce the supra-anal lobe of the adult, has a distinct dorsal emargination at the tip in *C. atra*, but there is not a sign of it in *nigra* (fig. 2). By analogy, the tenth

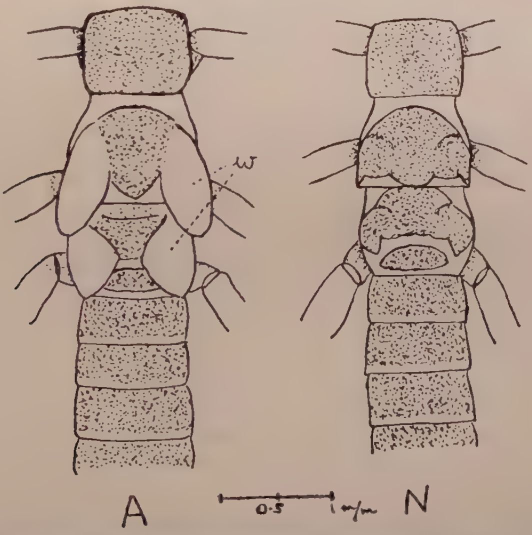

FIG. 3.—Dorsal view of thorax and front part of abdomen of ♂ of A, *Capnia atra* and N. *C. nigra*, showing well-marked wing-rudiments (w) in the former.

tergum of the male *vidua* nymph should be intermediate; but the emargination is not likely to be conspicuous, since that in the adult is much less so than in *atra*, and in the nymph it is likely by analogy to be less marked still. It should, however, be possible to separate the male *vidua* nymph from that of *atra* by the undeveloped wing-rudiments, and from that of *nigra* by having a slightly emarginate tenth tergum; it will be interesting to see if this is so, when it is discovered.

The female nymph.—As stated above, the female nymphs of *nigra* and *atra* are very similar. It was noticeable, however, that nymphs which gave rise to female *nigra* were on the whole larger than those which produced *atra*; one of these larger nymphs, full-grown, measured 8·0 mm., and three of the smaller type averaged 6·6 mm.; but it is probable that the two species overlap in this character. There was also some indication that the pronotum of nymphs giving rise to *atra* females was more quadrate and straight-sided, while those producing *nigra* had a pronotum with sides, anterior and posterior borders and angles more rounded; this difference is illustrated in fig. 4. It is pointed out, however, that insufficient material was studied for me to be completely satisfied with this character, and its examination was rendered more difficult by the fact that the pronotum of the nymphal skin is largely destroyed when the adult emerges and can be identified; further study with a greater wealth of material may confirm this distinction or reveal others, but for the time being it appears safest to rely on the male for determination.

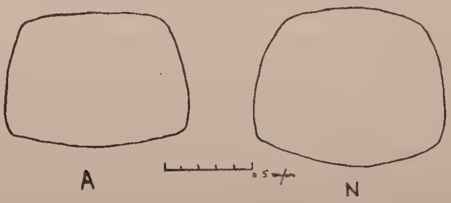

Fig. 4.—Outline drawings of pronotum of adult female nymph; A, probably *Capnia atra*; N, probably *C. nigra*.

Details of the habitat.—St. Mary's Loch is a large lake between three and four miles long, and nearly half a mile wide. The *Capnia* colony was discovered on the west side, on a stony shore partly shaded by trees; the bottom was unstable, and there was no vegetation except a rather slimy, yellowish-green coating, resembling filamentous algae, over most of the stones; a sample of this sent to the Freshwater Biological Association has been identified as *Leptomitus lacteus* (a sewage fungus!), with a little *Zygogonium ericetorum*; unicellular diatoms attached to the filaments of the former gave it its colour. The water was clear, and alkaline; the pH value varied between 8·0 (31 Dec. 1944) and 8·5 (25 March 1944): it was shallow, with a very gentle slope, and the marginal stones under which many of the nymphs were found were partly out of water. The fauna, besides the two *Capnia* species, included nymphs of the stoneflies *Dictyopterygella bicaudata* (L.) and *Nemoura avicularis* Mort., the water-beetles *Deronectes elegans* Panz., *Platambus maculatus* L. var. *inornatus* Schl., and *Hydraena gracilis* Germ., and large numbers of the Crustacean *Gammarus*.

Rearing the nymphs in captivity.—Nymphs were placed in very shallow water in petri-dishes, with a pebble or two, coated with the slimy mixture of alga and fungus, taken from their natural habitat. Here the majority survived and emerged without much trouble, and young nymphs grew to maturity.

No macroscopic (and probably little if any microscopic) animal matter was present in the pabulum, and it may therefore be safely assumed that the nymphs are, at any rate principally, vegetable feeders; this is in agreement with what Hynes (1941) states for *C. nigra*, and it is significant that his table (pp. 530–1) showing the results of analyses of gut-contents indicates that a higher percentage of nymphs contain diatoms than any other recognisable food.

A few nymphs experienced difficulty at the point of emergence, which process was arrested at the beginning with subsequent death of the partly emerged adult. The water was seldom changed, but merely replenished from the tap as it evaporated. The lid of the petri-dish was generally placed on the top when an emergence appeared due, but when this was omitted the adult was usually to be found subsequently on the underside of the dish; it thus behaved in the negatively heliotropic manner which is evidently natural, for adults of both species found at the margin of the loch were generally beneath pebbles.

Details of some of the emergences in captivity of nymphs collected on 1 April 1944 were as follows :—

Date of emergence	*C. atra*	*C. nigra*
1 April	1	
7 April		2
11 April		1
14 April		2
23 April	1	

In view of the capture of adults of *C. atra* on 24th March, this month should be added to the flight period of this species given by Hynes in his table (1940).

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A NOTE ON THE IMPORTANCE OF *EOLESTES SYNTHETICA* COCKERELL IN THE PHYLOGENY OF THE ODONATA

By Lt.-Col. F. C. Fraser, I.M.S., Retd., F.R.E.S.

A study of Professor Cockerell's paper (1940) on his Eocene fossil species *Eolestes synthetica* has revealed a peculiar error, the origin of which I am at a loss to explain, and through the error, the overlooking of the full importance of his find. Two factors may have operated to produce this error, one being his employment together of two different systems of notation, and the other the fact that the beginnings of the main veins in the fossil wing were either hidden or not at all clear. The employment of three different systems of notation in the Odonata, viz., the early Selysian, the later Comstock–Needham and the most modern Tillyardian, has always proved a source of confusion of ideas to me so that I am in full sympathy with Professor Cockerell if this be the main cause of his error. The latter requires early correction since it has resulted in a misinterpretation of the venation of this important and interesting species. Beginning from the Costa, the author has dealt with the main veins in rotation, but has entirely omitted mention of *Miii*, apparently confusing it with *Rs*, for the error occurs just at the point where he switches from the Selysian to the Needham notation. Thus *Miii* has been designated as *Miv* and, as a natural result, all subsequent veins have been misinterpreted for those immediately preceding them. The final consequence is that the last vein, *Cuii* (Anal vein) has been lost sight of altogether.

In the original fossil as it stood, the bases of the wings were obscured, so that it was not possible to see the origin of the main veins or the shape of the quadrilateral. Professor Rodeck, whose aid was called in, subsequently uncovered portions of the basal venation, but although it was possible to describe the shape of the quadrilateral and to make accurate measurements of the petiole and other portions of the base of the wings, the total result was not sufficiently clear to obtain a good photograph. From these details and by working out the ratio of the measurements obtained to those of the wing-figure given by the author, I have been able to make a reconstruction of the entire wing which I believe contains a large measure of accuracy. Moreover it has enabled me to furnish a correct interpretation of the main venation of the wing and to see wherein lies the full importance of this new discovery.

In his interpretation of the wing venation, Professor Cockerell, after dealing with the main veins as far as the subnodal one, proceeds to describe the " Median sector," but gives the notation as " *Miv* " in parenthesis after it, the Selysian Median sector being actually " *Miii*." He also states that— " . . . the Median sector (*Miv*) remains parallel with and closely following the subnodal sector—suggesting *Megalestes*," whereas it is *Miii* which fulfills this condition both in *Eolestes synthetica* and *Megalestes*. As a result of this confusion of veins, his *Cui* is actually *Miv* and his *Cuii*, *Cui*, whilst, having now exhausted his notation, he is left to describe *Cuii* as " a dense reticulation of cells below *Cuii*."

Employing the Needham–Comstock notation and the same phraseology as Professor Cockerell, the following should be the correct interpretation of *E. synthetica* after the description given for the subnodal sector :—

(10) Below the subnodal sector is a regular series of simple cells, the outer ones much higher than long, this agreeing essentially with *Megalestes*. Thus the Median sector (*Miii*) remains parallel with and closely following the subnodal sector, quite unlike *Ortholestes* but suggesting *Megalestes*.

(11) Below the Median sector, from the level of the subnodus out, are first seven simple cells, then six or seven double ones, after which there are three or four small cells in a transverse row. This is suggestive of *Archilestes*.

(12) *Miv* and *Cui* are separated by a row of simple cells as in *Ortholestes*.

(13) *Cui* and *Cuii* are also separated by a single row of cells but of very irregular size and shape. *Cui* runs almost flat to the posterior border of the wing which it reaches at a point about three-fourths of the way from the nodus to pterostigma.

(14) *Cuii*, quite shortly after leaving the quadrilateral, *bifurcates into two zigzagged branches* which are at first separated by a single row of cells for a distance of five cells and then by two rows of cells for a distance of nine cells, after which they converge again and appear to fuse and run again as a single vein to wing border. *There is no parallel to this condition amongst the* LESTIDAE *either fossil or recent.*

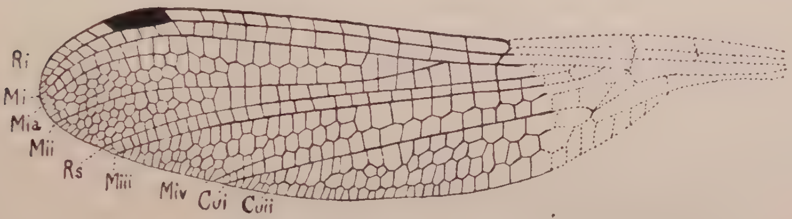

FIG. 1.—Fore-wing of *Eolestes synthetica* Cockerell (Eocene) reconstructed from a photograph and descriptions of the type. The reconstructed portion is shown in dotted outline.

It is in this last character, viz., the branched *Cuii* that the full importance of this new fossil wing lies, for it supplies a possible and, I think, probable clue to the origin of the Agrioidea. The LESTIDAE have been regarded as the most probable ancestors of the Agrioidea on account of the advanced recession of the main veins *Rs* and *Miii*, which is common to them and to the higher Zygoptera, but no connecting links have hitherto been found binding them to either the MEGAPODAGRIIDAE or AMPHIPTERYGIDAE through which families the line of evolution is conjectured to have passed. In *Argiolestes* of the former family, there is a branching of the Anal vein (*Cuii*) not unlike that seen in the present species, but in that genus there is no sign of any recession of *Rs* or *Miii*. The next step in the evolution of the LESTIDAE towards the Agrioidea would be a multiplication of the antenodal veins and a broadening of the basal part of the wing by a branching of the Anal vein immediately after the level of the quadrilateral. This latter stage is exhibited in *Eolestes*, which thus supplies us with another link in the chain of evolution. It is a matter for regret that the basal portion of this wing was not better preserved, for it seems to me highly probable that supplementary antenodals were actually present and I find it hard to believe that although present in *Dysagrion*, an allied fossil genus from the same horizon, but with an incomplete recession of *Rs* and *Miii*, they are said to be absent in *Eolestes*. The fossil should be carefully examined again for the presence of these important structures and if the result should be positive, then an important step will have been made towards solving the phylogeny of the higher Zygoptera.

It is to be noted that *Cuii* is not only bifurcated in *Eolestes*, but that a short intercalated vein is present between the two branches, which by very little lengthening, as is the usual course of evolution in these veins, would soon convert the dichotomy into a triad such as is found in *Cyanocharis* and throughout the POLYTHORIDAE. The origin of these neotropical families is unknown but it seems evident that, like the rest of the Agrioidea, they came from a Lestine ancestry.

Professor Cockerell, following Calvert, has given a masterly summing-up of the possible relationships of his new genus, but, I think, has laboured unnecessarily to prove a closer relationship with the New World genera. As a matter of fact, by his own showing, the relationship appears to lie closest to the Oriental *Megalestes* and, through this genus, to the SYNLESTIDAE. But *Eolestes* is not a Synlestine; it lies on a much higher evolutionary plane and must be regarded as belonging to those later ancestral types from which the Agrioidea arose. Professor Cockerell is to be congratulated for bringing to our notice a fossil which will become historic.

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THE EFFECT OF GRAIN SIZE ON THE OVIPOSITION OF *CALANDRA GRANARIA* LINN. (COLEOPTERA, CURCULIONIDAE)

By R. F. Ewer.

The following series of experiments was carried out in order to ascertain what rôle, if any, grain size plays in determining the selection of oviposition sites by *Calandra granaria.* If grain size is of importance then it should be taken into account in any experiments on oviposition. It might also affect the distribution of eggs in large masses of wheat.

Material and Methods.

All experiments are carried out at 25° C. and 70% relative humidity, using English wheat grains previously brought into equilibrium with 70% R.H. O. W. Richards (unpublished) has shown that such conditions are suitable for *Calandra granaria.*

Since the sexes can be distinguished in the adult *Calandra* by differences in the shape of the last abdominal tergite, females can be picked out of a mixed culture. For all experiments females not older than three weeks are used, and their oviposition rate tested by counting the eggs laid in single wheat grains for several successive 2-day periods. Any weevils which fail to lay, or lay only very small numbers of eggs are rejected. The remainder are referred to as "tested laying females."

The eggs are laid inside the grains, so dissection is necessary if an exact count of the eggs is to be made. This is most conveniently done by soaking the grain for twenty-four hours in 70% alcohol; this softens the grain and it can then be dissected with a needle and the eggs counted. Egg lay can be assessed by counting the number of egg plugs visible on the surface of the grain (Eastham and McCully, 1943). This method is not completely satisfactory, since in some positions on the grains the plugs are very difficult to detect with any certainty. Eastham and McCully record that about 8% of eggs are missed when this method of counting is used.

Experimental.

1. *Experiments with individual grains.*

Twenty-four tested laying females were chosen and placed singly for 2-day periods in 3 × 1″ glass tubes each containing one large and one small wheat grain. The large grains were over 55 mg. and the small under 40 mg. in weight. The eggs laid in each grain were counted for successive 2-day periods: the results are given in Table 1. It will be seen that a definite preference for the large grains was shown: they contained 66·6% of all the eggs laid.

It was next desirable to find out whether large and small grains must be present simultaneously if the preference for the large is to be shown. The same weevils as were used previously were therefore divided into two batches of twelve each. Lot A were then given single small or large grains for alternate

TABLE 1.

Weevils given 1 large and 1 small grain for 2-day periods.

2-day period number		1	2	3	4	5	6	7	Mean of all periods
Eggs in small grain	Total	39	39	52	50	39	39	39	
	Percent.	34	34	34	31	37	34	30	33·4
Eggs in large grain	Total	75	77	101	111	66	76	83	
	Percent.	66	66	66	69	63	66	70	66·6

2-day periods: lot B were similarly treated except that while A were on small grains B were on large and vice versa. This will minimise any errors due to chance variations in the external conditions. One female from lot B was lost, so this batch consisted of only eleven weevils. Since an even number of 2-day periods was used this should not affect the validity of comparing total egg numbers, and will in any case have no effect on the results expressed as eggs laid per female. The results are given in Table 2. The total number of eggs laid in the small grains was 410 and in the large 530, or 43·6% in the small and 56·4% in the large grains. Comparing the mean oviposition rates per female in the two grain sizes the difference found is 1·32 ± 0·286 eggs per female per 2 days, which is significant. Thus giving the grains alternately instead of simultaneously reduces but does not abolish the preference shown for the large.

TABLE 2.

Weevils given 1 large or 1 small grain on alternate 2-day periods.

2-day period number		1	2	3	4	5	6	7	8	Mean of all periods
Eggs in small grain	Total	59	57	59	49	57	38	52	39	
	Eggs per ♀	4·92	5·18	4·92	4·46	4·75	3·45	4·33	3·55	4·45 ± 0·23
Eggs in large grain	Total	70	74	62	73	66	61	63	61	
	Eggs per ♀	6·36	6·17	5·64	6·08	6·00	5·08	5·73	5·08	5·77 ± 0·17

I have found previously (unpublished) that very few eggs are laid in grains which already contain a fourth-instar larva. It thus seemed possible that a grain might cease to be attractive for oviposition after a certain number of eggs had been laid in it, and that this "saturation number" might be less for small than for large grains. Two further experiments were therefore made, as before, except that the weevils were only allowed to lay for one day at a time, thus reducing the number of eggs per grain. The results are given in Table 3. When the grains are given simultaneously 67·5% of all eggs are laid in the large grains. These figures differ little from those found for 2-day periods, and indicate that the preference is not due to a saturation effect. This does not, of course, preclude such an effect showing itself at higher rates of egg lay, or in different conditions. The results for the grains given alternately for 1-day periods are equivocal: 53·9% of the eggs were laid in the large and 46·1% in the small grains. This difference is not significant.

TABLE 3.

Weevils given large and small grains for 1-day periods.

1-day period number	Grains presented simultaneously		Grains presented on alternate days	
	Eggs in small grain	Eggs in large grain	Eggs in small grain	Eggs in large grain
1	21	37	26	25
2	19	44	23	27
3	23	50	26	29
4	23	36	30	37
5	11	34	31	34
6	—	—	25	36
Total . .	97	201	161	188
Percent. .	32·5	67·5	46·1	53·9

2. *Experiments in cultures consisting of selected large and small grains only.*

It is not impossible that the preference shown in the experiments just described is really an artifact caused by the unnatural experimental conditions. When a grain is lying loose in the bottom of a tube it may roll about and so make oviposition difficult. This difficulty would be greater the smaller and lighter the grain, but would be abolished in a mass of wheat where movement of individual grains is restricted. In order to test this two small cultures containing approximately 12 g. of grains were set up. The cultures consisted of large and small grains separated by sieving, intermediate sizes being rejected. Culture A consisted of equal numbers of large grains of mean weight 59·9 mg. and small grains of mean weight 30·7 mg. Culture B contained 116 large grains of mean weight 63·1 mg. and 185 small grains of mean weight 30·0 mg. If it is assumed that the grains are of similar shapes, then the surfaces can be taken as very nearly proportional to the two-thirds power of the weight (Rubner, 1883), and culture B thus contains approximately equal surfaces of large and small grains. If more eggs are laid in large than in small grains merely because the total surface area of the former is greater we should expect the total numbers of eggs in the two grain sizes to be equal in culture B.

Fifteen tested laying females were put on each culture and left for five days to lay. They were then removed, the grains sorted into large and small and dissected. The numbers of eggs found were as follows :

Culture A. Eggs in small grains 28 = 21·2% of total.
,, large ,, 104 = 78·8% ,,
Culture B. Eggs in small grains 62 = 37·8% of total.
,, large ,, 102 = 62·2% ,,

The preference is thus not abolished in a mass of grain, nor does it appear to be simply a question of available surface areas.

The possibility that large and small grains from the same mass of wheat might have different equilibrium water contents was also investigated. Samples of large and small grains were separated by sieving, and the water content of each determined. No difference was found.[1]

It was next thought desirable to find out whether in a non-random arrangement of grains the weevils would still lay preferentially in the larger. Equal weights (about 10 g.) of large and small grains were separated by sieving and put in a small beaker (4·2 cm. diameter) in such a way that left and right halves of the beaker were filled with small and large grains respectively. Eight laying females were put on and left for ten days to lay. The grain was then sorted and samples of 100 large and 100 small grains dissected. Four such experiments were done, and the results are given in Table 4. The results are somewhat indecisive. It seems probable that the animals wander through the grain uninfluenced by its size, and choose one for oviposition wherever they happen to be when ready to lay. If this occurs in the boundary zone where a choice is possible, this might account for the slight and variable degree of preference shown. It should, of course, be borne in mind that in these experiments the small grains have a greater total surface area than the large. This means that if referred to unit surface area the preference for the large grains is greater than appears from Table 4. However, even if some preference is still shown, these experiments demonstrate that the weevils do not avoid the small grain side of the beaker, and so presumably grain size has little effect on their distribution.

TABLE 4.

Non-random arrangement of large and small grains.

Culture number	Eggs per 100 grains (counted)	Total eggs (calculated)	% of all eggs laid (calculated)
1. Small grains	35	124	41
Large grains	93	179	59
2. Small grains	44	115	53
Large grains	73	102	47
3. Small grains	67	187	49
Large grains	130	196	51
4. Small grains	40	116	40
Large grains	120	177	60

3. *Experiments in cultures consisting of grains of all sizes.*

It still remains possible that the preference shown in these experiments might not appear under natural conditions where there is no sharp contrast between large and small grains. Experiments to test this were set up. Five arbitrary weight classes 20–29·99, 30–39·99, . . . 60–69·99 mg. were chosen. This covers the whole range of weight normally present in English wheat in equilibrium with 70% relative humidity. Fifty grains of each weight class were picked out, and those in each class given a small distinguishing mark in Indian ink. Owing to the scarcity of the very small grains only eighteen in the 20–29·99 mg. class were marked in the first and thirty-nine in the second experiment. These marked grains were then thoroughly mixed with sufficient of the wheat from which they had originally been picked out to make the whole up to 50 g. Twenty-five female *Calandra* were then put on and left to lay for ten days. The marked grains were then picked out and dissected. The results are given in Table 5.

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[1] I am indebted to Mr. J. D. Jones for making these determinations, and allowing me to quote his results.

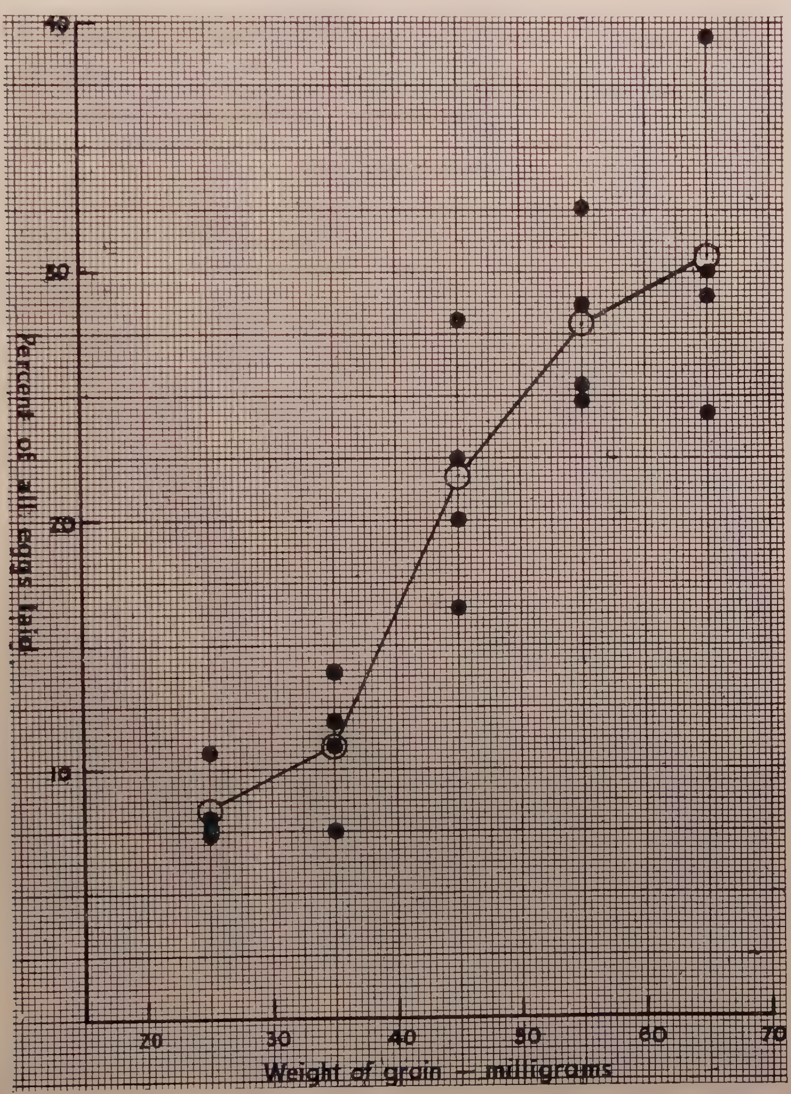

Fig. 1.—Percentage of eggs laid by female *Calandra granaria* in wheat grains of different sizes. Data from Table 5. Separate experiments shown as small black circles: mean as large open circles.

The weevils themselves show a considerable variation in size; the weights normally encountered in our cultures ranged from about 1·3 to 3·0 mg. Two further experiments were therefore made, using selected small and large females of mean weights 1·67 and 2·55 mg., respectively. The results of these two experiments are included in Table 5, and fig. 1 expresses the data from this table graphically.

Table 5.

Small cultures of unselected grains. Experiments 1 and 2, unselected females; 3, small; and 4, large females.

Grain weight (mg.)		20–29·99	30–39·99	40–49·99	50–59·99	60–69·99
Eggs per 100 grains.	Exp. 1.	28	40	102	104	88
	Exp. 2.	28	48	78	88	104
	Exp. 3.	16	26	36	54	86
	Exp. 4.	34	24	64	104	92
Percent. of total.	Exp. 1.	7·7	11·1	28·2	28·7	24·3
	Exp. 2.	8·1	13·9	22·5	25·4	30·1
	Exp. 3.	7·3	11·9	16·5	24·8	39·5
	Exp. 4.	10·7	7·5	20·1	32·7	29·0
	Mean of 4 expts.	8·4	11·1	21·8	27·9	30·7

It will be seen that the preference still exists when all sizes of grain are present, and that the small weevils do not show any less preference than the large ones.

Discussion.

Calandra granaria has been shown to lay eggs more readily in large than in small grains of wheat; but the factors determining this preference have not been elucidated. Grains may of course differ from each other not only in weight and radius of curvature, but also in physico-chemical constitution. Either type of difference might be responsible for the choice shown by the weevils. In the last described set of experiments small *Calandra* did not show any less marked preference than large ones, and this would seem to favour the view that it is physico-chemical differences in the grain, rather than size *per se*, which influence the behaviour of the animals. Differences in equilibrium water content of different sized grains have been ruled out, but other factors have not been investigated. In this stage therefore it is not possible to say more than that the preference exists, and that in any experiments necessitating uniformity of egg lay it is desirable to use grains of fairly uniform size.

Summary.

Calandra granaria females lay more eggs in large wheat grains than in small ones. This is true not only when large and small grains are presented simultaneously and a choice is possible, but also when the weevils are given large or small grains for alternate 1- or 2-day periods.

The preference is shown in a mass of normal wheat as well as in experiments where the animals are given selected large and small grains offering a sharp contrast.

The preference is not due to differences in equilibrium water content of large and small grains, nor can it be accounted for by grains becoming unsuitable for oviposition if they contain a certain number of eggs.

This work was carried out at the Imperial College Biological Field Station at Slough, and my thanks are due to Professor J. W. Munro for his hospitality and to Dr. O. W. Richards for advice and assistance throughout the course of the work.

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RUBNER, M., 1883, Über den Einfluss der Körpergrösse auf Stoff- und Kraftwechsel. *Z. Biol.* **19** : 536–62.

Book Notices.

A Revision of Nearctic Dorilaidae (Pipunculidae). By D. Elmo Hardy. 8vo. Lawrence, Kansas, 1943. (University of Kansas Science Bull. **29 :** 1.) pp. 231; 18 plates.

This is a monographic study of all the known Nearctic species of the Dipterous family Dorilaidae, bringing up to date the taxonomy and known data concerning these flies. Fourteen world genera and one subgenus are described, and one genus is described as new. One hundred and seventeen species, subspecies, and varieties are discussed, and twenty-seven described as new. The work forms Part I of a thesis submitted to the Department of Entomology and the faculty of the Graduate School of the University of Kansas in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

The Butterflies and Moths (Lepidoptera) of Iraq. Their distribution, phenology, ecology and importance. By E. P. Wiltshire. 8vo. Baghdad. 1944. (Agricultural Directorate Baghdad Bull. **30**.) pp. 101; 1 plate.

In this book, which comprises an annotated catalogue of the Macro-Lepidoptera of Iraq, special attention is given to the ecology of all the species listed, and also to those of economic importance and those most likely to attract the notice of the lay resident in Iraq. Descriptions of a few Pyralididae and Micro-Lepidoptera of considerable economic importance are included in an appendix, as the author hopes to publish at a later date a comprehensive catalogue of these insects as a continuation of the present work.

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MEETINGS

TO BE HELD IN THE SOCIETY'S ROOMS

41, Queen's Gate, S.W.7

1945.

WEDNESDAY, October 3
,, November 7
,, December 5

1946.

WEDNESDAY, January 16 (ANNUAL MEETING)
,, February 6

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

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